TITLE OF INVENTION: SUGAR JUICE CLARIFIER APPARATUS

INVENTOR: Richard Wilfred Wright

RESIDENCE: 10848 Hillmont Ave.,
Baton Rouge,
Louisiana. 70810.
U.S.A.

CITIZENSHIP: South Africa

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BACKGROUND OF THE INVENTION

01. This invention relates to a raw mixed sugar juice clarification apparatus that allows precipitation, subsidation and separation of insoluble and mud particles in sugar juice in a more efficient way than that which is presently practiced in the international sugar industry.

02. Physical and chemical purification of raw mixed sugar juice is currently practiced in the sugar industry by the addition of lime and sometimes, additional substances that cause a precipitate to form within the sugar juice. This precipitate, sometimes including a polyelectrolyte flocculant, entraps suspended impurities in the juice. Due to the difference in densities between the precipitate and the clear juice; the precipitate sinks to the lower region of the conventional clarifiers used in the industry. The clear (purified) juice, due to its lower density; rises to take-off points in the upper section of conventional clarifiers.

03. Whilst there are various clarifier designs currently being used in the industry; they all have a common operational disadvantage. This is that the raw mixed juice requires

even and gentle distribution into the clarifier body together with an equally even and gentle extraction of the clear juice and precipitate in order to permit vertical rising of the clear juice and vertical settlement of the precipitate in a turbulence-free environment.

04. This condition of turbulence-free vertical 'plug flow' is practically impossible to achieve with the current designs of fixed, multi-point inlet and outlet facilities for the incoming juice and outgoing precipitate (mud). Pure 'plug flow' would necessitate an infinite number of inlet and outlet facilities spread over the entire cross section plan of the clarifier vessel. Conventional clarifiers consequently operate on a compromise between vertical plug-flow and horizontal flow, which is necessary in order to distribute and extract the juice and precipitate (mud), into and out of the clarifier body. The turbulence caused by the interaction of vertical and horizontal flow patterns results in flow short-circuiting and semi-stagnant zones within the contents of the clarifier. Flow short-circuiting and semi-stagnant zones produce a variation in the residence time of the juice in the clarifier. This turbulent condition also affects the gravitational rate of settlement of the precipitate thus requiring a larger volume for settlement than a volume free from turbulence. A larger volume clarifier results in a longer average retention time for juice in the clarifier. Sugar juice degrades with time and a loss of sucrose through inversion takes place, therefore the shortest retention time of sugar juice in a clarifier is a distinct production advantage.

BRIEF SUMMARY OF THE INVENTION

05. A continuous process of treated raw mixed sugar juice clarification by means of the settlement of insoluble particles and juice precipitate in a vessel that permits non-turbulent vertical subsidation and short retention time of the sugar juice. The relatively large, non-turbulent settling zone of the clarifier is maintained by the continuous advancement of the mixed juice entry and clear juice and mud extraction station which rotates within and around the annular shaped cylindrical clarifier thus permitting efficient, vertical, turbulent-free subsidation of the mud and precipitate.

BRIEF DESCRIPTION OF THE DRAWINGS

06. Figure 1 illustrates an isometric view of a typical clarifying apparatus in accordance with the first embodiment of the invention.

07. Figure 2 illustrates a sectional view through the body, bridge and rotating arm of a typical clarifying apparatus as shown in Figure 1, sectioned along the centerline of the bridge and rotating arm.

08. Figure 3 illustrates a plan view of a typical clarifying apparatus in accordance with the first embodiment of the invention.

09. Figure 4 illustrates an isometric view of a typical clarifying apparatus in accordance with the second embodiment of the invention.

10. Figure 5 illustrates a sectional view through the body, bridge and rotating arm of a typical clarifying apparatus as shown in Figure 4, sectioned along the centerline of the bridge and rotating arm.

11. Figure 6 illustrates a plan view of a typical clarifying apparatus in accordance with the second embodiment of the invention.

DETAILED DESCRIPTION OF THE INVENTION

12. According to the invention, the vertical path of the settlement of the precipitate (mud) and the consequential vertical rise of the clear juice in the shortest possible time is achieved by means of the maximum elimination of turbulence, cross currents and subsequent eddy currents within the volume of the juice contents of a cylindrical, annular clarification vessel. The reduction of the turbulence and cross currents in the annular volume of the clarifier body is achieved by the elimination of raw mixed juice introduction and precipitate and clear juice extraction in the major clarification sector of the annular volume of the clarifier body, thus leaving the contents of this volume turbulent-free to achieve efficient separation through subsidence.

13. A moving section (arm) that rotates around the center of the cylindrical shaped clarifier body performs the introduction of the raw mixed juice and the extraction of precipitate (mud) and clarified juice. This rotating arm allows the liquid feed and discharge streams of the clarifier to rotate around the center of the clarifier thus leaving the majority of the contents of the clarifier undisturbed by any turbulence caused by

these incoming and outgoing flows. The rotating arm section, where the incoming and outgoing flows occur, may include a baffle arrangement to control and direct the respective flows. In the first embodiment, the rotating arm is attached to a rotating hub, which is centered in the clarifier body and contains three concentric annual compartments, which provide the means of entry for the incoming raw mixed juice and for the exit of clear juice and precipitate (mud). The liquid levels in these three annular compartments dictate the respective rates of flow of the incoming raw mixed juice and the outgoing clear juice and precipitate (mud). Adjustments to these levels will influence the respective flow rates thus also affecting the ratio of the split of the extraction of clear juice and precipitate (mud).

14. Extraction pumps with variable rates of pumping may be used to maintain the respective levels in the clear juice and precipitate (mud) annular compartments in the central hub. A simple level control system may be incorporated in the clear juice and precipitate (mud) compartments of the central hub such that the extraction pumps will remove the clear juice and precipitate (mud) in a predetermined ratio, at the same collective rate of the incoming mixed juice, thus ensuring hydraulic equilibrium of the flows in and out of the clarifier.

15. As a second embodiment, alternative to the use of variable flow pumps for the extraction of the clear juice and precipitate (mud) in predetermined ratios, the extraction piping from the clear juice and precipitate chambers of the rotating arm may be arranged in siphon configurations such that the extraction of clear juice and precipitate from the respective chambers to non rotating tanks in the center of the clarifier, would be automatic. The rate of siphoned extraction of clear juice and precipitate is dictated by the liquid level differential between the tanks on either side of the siphons. The two concentric, central and non rotating tanks are connected to a weir box on the perifery of the clarifier body by means of two 'U' shaped pipe manifolds beneath the clarifier. The liquid levels in the central concentric non rotating tanks are controlled by adjustable height weir plates in the weir box. By raising or lowering each weir plate, the respective product outflow from the clarifier is decreased or increased by the liquid level differential.

16. The rotating arm section of the clarifier is fitted with adjustable weir slots or cut-outs to allow for the proportionate flows of all liquids coming into and going out of the

clarifier body and allows for the differential in flow rates between the inner and outer circumferential volumes of the cylindrical body contents of the clarifier.

17. The lower chamber of the rotating arm which collects the precipitate (mud) may also be fitted with angled scraper blades that direct the settled mud towards the central hub, through the rotational movement of the arm on the base of the cylindrical clarifier bottom.

18. The lower trailing skirt edge of the lower compartment, where it moves over the base of the cylindrical clarifier body bottom, is fitted with a flexible wiper seal to contain the precipitate (mud) in this compartment. The rotating arm assembly, together with either its integral central hub of concentric annual compartments or as in the latter embodiment, with its mixed juice infeed pipe manifold; is pivoted in the center of the cylindrical clarifier body and is driven at a fixed rotational speed by means of either a central or peripheral drive. The rotational speed of the arm assembly in the clarifier will dictate the residence time of the juice in the clarifier.

19. The rotating arm assembly with either its central hub of compartments or mixed juice infeed manifold; is supported and rotated from a fixed structural bridge which straddles across and over the diameter of the clarifier body. This bridge also supports the rotating arm reduction speed drive system.

20. The turbulent-free liquid contents of the clarifier is maintained by the balanced extraction of clear juice and precipitate on the leading edge of the rotating arm against the equivalent volume replacement of introduced raw mixed juice off the trailing edge of the arm as it rotates around the center of the clarifier.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

21. With reference to the Figures 1, 2 & 3 drawings, the clarifying apparatus in accordance with the first embodiment of the invention consists of a body in the form of a cylindrical, open top, tank **1** which houses a rotating arm **2** that continuously rotates through the circular extent of the tank **1** and pivots on the center of the tank **1** through the central rotating hub **3** to which the arm **2** is fixed. The complete rotating assembly **2 & 3** is suspended from the center of the fixed bridge **9** by means of a slewing bearing assembly **8** and this form of support of the rotating assembly may also be augmented or substituted by an additional submerged bearing unit beneath the hub **3** and on the

center of the bottom of the tank **1**. For clarity, this additional bearing unit is not shown on the drawings.

22. The fixed bridge **9** is a structural member that spans the diameter of the tank **1** and is sufficiently stiffened to support the rotating assembly **2 & 3**, the drive unit required to rotate the assembly and the three pipes **5, 6 & 7**. The three pipes **5, 6 & 7** protrude into the three annular, concentric chambers **10, 11 & 12** of the rotating hub **3** to provide product flows into and out of the clarifier. The entry of mixed juice into chamber **10** is through pipe **5** whilst the extraction of clear juice and precipitate out of chambers **11** and **12** is through pipes **6** and **7** respectively.

23. The incoming mixed juice passes from chamber **10** through an orifice in the outer wall of chamber **10** into the middle compartment **14** of the rotating arm **2** which is fitted with variable width slots **4** on its leeward side to allow even distribution of the mixed juice into the clarifier body **1**.

24. The separated clear juice, which has risen to the top of the contents of the clarifier **1**, immediately in front of the rotating arm **2**, is extracted through the variable width slots or cut outs **4** on the upper edge of the leading edge of upper compartment **13** of the rotating arm **2**.

25. The separated precipitate (mud), which has subsided to bottom of the contents of the clarifier **1**, immediately in front of the rotating arm **2**, is extracted through the variable width slots or cut outs **4** on the lower edge of the leading edge of lower compartment **15** of the rotating arm **2**. Angled scraper blades which may be incorporated in the lower compartment **15** to assist the mud flow towards the central hub chamber **12** are not shown for the sake of clarity. The lower skirt edges of the sides and trailing edges of the lower compartment **15**, where it moves over the base of the cylindrical clarifier body bottom **1**, is fitted with a flexible wiper seal to contain the precipitate (mud) in this compartment **15**.

26. The separated clear juice and precipitate (mud) travel along their respective chambers **13** and **15** in the rotating arm **2** towards their respective central annual chambers **11** and **12** by means of liquid level differentials between the clarifier body liquid level and the respective liquid levels in chambers **11** and **12**. These differentials may be maintained by variable speed extraction pumps or siphoning extraction piping with or without level control equipment, all of which is not shown in the drawings for sake of clarity.

27. The rotating arm **2** which is depicted as a three chamber, rectangular sectioned structure for ease of illustration; may have a variety of cross sectional shapes of the three axial chambers **13, 14 & 15** to suit the increasing and decreasing capacity flows along the radial route of the respective content flows to and from the hub **10, 11 & 12**. These variances to the cross sectional shape of the arm **2** may also include the leading and trailing faces of the arm **2** to allow for hydraulic flow gradients and/or streamlining in order to reduce the creation of turbulence through eddy currents on both the leading and trailing zones of the arm **2** in the contents of the clarifier body **1**.

28. In order to conserve the heat of the juice in the clarifier, the body **1** may be insulated and covered with a circular roof covering with suitable cut outs for ancillary equipment and inspection ports.

29. With reference to the Figures 4, 5 & 6 drawings, the clarifying apparatus in accordance with the second embodiment of the invention consists of a body in the form of a cylindrical, open top, tank **16** which houses a rotating arm **17** that continuously rotates through the circular extent of the tank **16** and pivots off the central slewing bearing **18** located on the drive bridge **19** on the centerline of the tank **16** through the central mixed juice inlet pipe manifold **20** which is connected to the rotating arm **17**.

30. The complete rotating assembly **17, 20, 21 & 22** is suspended from the center of the fixed bridge **19** by means of a slewing bearing assembly **18** and this form of support of the rotating assembly is also augmented by wheels **23** mounted on brackets **24** affixed to the outer corners of the rotating arm **17**. These wheels **23** run on the stiffened top rim of the clarifier body **16**.

31. The fixed bridge **19** is a structural member that spans the diameter of the tank **16** and is sufficiently stiffened to support the rotating assembly **17, 20, 21, 22, 23 & 24** and the drive unit required to rotate the assembly **17, 20, 21, 22, 23 & 24**.

32. The sides of the two central, non rotating, concentric tanks **25 & 26** protrude above the normal operating level **27** of the clarifier and the siphon transfer pipe manifolds **21 & 22** pass over the top edges of, and into these tanks **25 & 26**. The inner precipitate tank **26** has a conical shaped bottom to facilitate the removal of the denser precipitate. Both tanks **25 & 26** discharge through two 'U' shaped manifolds **28 & 29** under the clarifier which connect to two weir boxes **30 & 31** which are fitted with vertically adjustable weirs **32 & 33**. The clear juice and precipitate outflows from the clarifier exit through pipes **34 & 35** attached to the bottom of the weir box.

33. The entry of mixed juice into chamber **36** of the rotating arm **17** is through pipe manifold **20** whilst the extraction of clear juice and precipitate out of chambers **37** and **38** is through siphon pipes **21** and **22** respectively.

34. The separated clear juice, which has risen to the top of the contents of the clarifier **16**, immediately in front of the rotating arm **17**, is extracted through the variable width slots or cut outs **39** on the upper edge of the leading edge of upper compartment **37** of the rotating arm **17**.

35. The separated precipitate (mud), which has subsided to bottom of the contents of the clarifier **16**, immediately in front of the rotating arm **17**, is extracted through the variable width slots or cut outs **39** on the lower edge of the leading edge of lower compartment **38** of the rotating arm **17**. Angled scraper blades which may be incorporated in the lower compartment **38** to assist the mud flow towards the precipitate siphon pipe **22** are not shown for the sake of clarity. The lower skirt edges of the sides and trailing edges of the lower compartment **38**, where it moves over the base of the cylindrical clarifier body bottom **16**, is fitted with a flexible wiper seal to contain the precipitate (mud) in this compartment **38**.

36. The separated clear juice and precipitate (mud) travel along their respective chambers **37 & 38** in the rotating arm **17** towards their respective central annual chambers **25** and **26** through their respective siphon pipes by means of liquid level differentials between the clarifier body liquid level and the respective liquid levels in chambers **25** and **26**. These differentials will be maintained by adjusting the heights of the weir plates **32 & 33** in the weir boxes **30 & 31**.

37. The rotating arm **17** which is depicted as a three chamber, rectangular sectioned structure for ease of illustration; may have a variety of cross sectional shapes of the three axial chambers **36, 37 & 38** to suit the increasing and decreasing capacity flows along the radial route of the respective content flows from the inlet manfold **20** and to the siphon pipes **21 & 22**.

38. These variances to the cross sectional shape of the arm **17** may also include the leading and trailing faces of the arm **17** to allow for hydraulic flow gradients and/or streamlining in order to reduce the creation of turbulence through eddy currents on both the leading and trailing zones of the arm **17** in the contents of the clarifier body **16**.